

The Effects of Exercise on Pregnancy Outcomes: A Systematic Review

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Abstract

Maternal morbidity continues to be a significant problem worldwide. Yet, for every woman who dies of pregnancy-related causes, 20 or 30 others experience acute or chronic morbidity, often with permanent sequelae that undermine their normal functioning. Health behavior interventions, such as increasing physical activity, have potential to reduce the incidence of complications of pregnancy, and reduce the burden of morbidity and mortality for families throughout the world. The purpose of this systematic literature review was to describe if physical activity before and during pregnancy affects the incidence of complications in first pregnancies or recurrence of complications in subsequent pregnancies. Databases used in this review were PubMed, CINAHL, Web of Science, and Cochrane and were searched with predetermined terms. Extensive electronic and manual citation searches were performed to identify relevant papers for review. Inclusion criteria were: full text articles published in English between the years 2003-2018, peer-reviewed, and performed on pregnant female human subjects. Screening, data extraction, and quality assessment were undertaken by two reviewers. Twenty-one studies were utilized in this review and classified by level of evidence, nature of physical activity, if women participated in physical activity before or during pregnancy, and maternal and infant pregnancy and birth data, and if the incidence of pregnancy complications was reduced when physical activity was increased. We described the incidence of pregnancy complications among women who participate in various forms of physical activity before and during pregnancy as reported by these studies. These data were presented in a summary table. Further research on increased physical activity and other health behavior interventions in pregnancy is needed. These data confirm the accuracy of current recommendations that

exercise in pregnancy is safe for mother and baby, but is limited in describing whether increased exercise reduces complications of pregnancy. Future research must aim to test exercise in pregnancy in a randomized, controlled, and supervised manner in order to accurately draw conclusions.

Chapter I: Introduction

Of the approximately 4 million women who give birth in the United States each year, the Centers for Disease Control and Prevention estimates that 50,000 of them will experience severe maternal morbidities. These are defined as “unexpected outcomes of labor and delivery that result in significant short or long term consequences to a woman’s health”(CDC, 2017). Though medical advancements continue to be made, maternal morbidity in the United States is still on the rise. It is unclear why complications of pregnancy continue to occur at such high rates, but early research suggests that increasing pre-pregnancy obesity rates and rising maternal age seen in modern pregnancies may be contributing factors. Preventing these complications from initially occurring can significantly enhance the health of both pregnant mothers and the babies they deliver.

Physical activity is widely known to reduce the incidence of disease processes throughout the lifespan, such as development of obesity, hypertension, diabetes, and cardiovascular disease. This raises the question of whether or not physical activity during pregnancy can have the same impact on reducing pregnancy related disease processes. The American College of Obstetricians and Gynecologists suggests that exercise in pregnancy is safe and proves beneficial to most healthy women (2015). Although some high-risk pregnancy situations may warrant reduction in exercise regimen during pregnancy, all women experiencing uncomplicated pregnancies are encouraged to continue to engage in normal moderate physical activity. The current recommendation is “at least 150 minutes per week of moderate-intensity aerobic activity” (American College of Obstetricians and Gynecologists, 2015). Just as in non-pregnant women, physical activity enhances physical fitness, provides weight management, and overall increases well-being. However, it

remains uncertain as to whether exercise during pregnancy aids in reducing the development of pregnancy complications. High quality studies on the subject, such as randomized control trials, are limited and have shown contradicting results. Pregnancy complications such as preeclampsia, gestational hypertension, and gestational diabetes mellitus occur in 20 percent of pregnancies and place mother and baby at risk for further problems during and after pregnancy. The rates of these complications are significant, as are the issues that occur as a result of them. The specific complications focused on in this review were gestational diabetes mellitus, preeclampsia and gestational hypertension, preterm birth, caesarean section, and excessive gestational weight gain.

Gestational Diabetes Mellitus

Gestational diabetes mellitus (GDM) is the new development of insulin resistance in pregnancy and impacts 2-18% of pregnancies worldwide (Russo, 2015). Known non-modifiable risk factors for the disease process include family history of diabetes, high-risk ethnicity (such as Hispanic), increased maternal age, previous delivery of macrocosmic infant, vitamin D deficiency, and excessive gestational weight gain early in pregnancy. Though these factors cannot be controlled, obesity and sedentary lifestyle can be greatly modified to reduce a woman's risk of developing GDM (Koivusalo, 2016). There are significant complications related to development of GDM both during and after pregnancy. Women diagnosed with GDM also have increased rates of preeclampsia, gestational hypertension, and fetal overgrowth. Large for gestational age infants place the mother at increased risk for caesarean section delivery, postpartum hemorrhage, and vaginal laceration during birth. The complications of GDM are not limited to pregnancy, delivery, or

the immediate period post-delivery. Women diagnosed with GDM are estimated to be at a 70% increased risk for developing type 2 diabetes mellitus later in life (Russo, 2015). The offspring of women with this disorder are also at increased risks for obesity, impaired glucose regulation, and gestational diabetes relative to children of healthy women (Koivusalo, 2016).

Preeclampsia and Gestational Hypertension

Preeclampsia is estimated to impact between 2-8% of pregnancies throughout the world, and even more concerning, accounts for 10-15% of all pregnancy related deaths (Duley, 2009). Following embolism and hemorrhage, the condition is the leading cause of death related to pregnancy. The American College of Obstetricians and Gynecologists defines the disease process as the measurement of a systolic blood pressure of equal or greater to 140, or diastolic pressure of equal to or above 90 occurring after 20 weeks of gestation in previously normotensive women. This combined with new-onset proteinuria constitutes the diagnoses of preeclampsia. Some women may experience symptoms such as rapid weight gain, swelling, headaches, and visual changes that alert them to a problem, but other women may not notice these drastic changes. Gestational hypertension is the new onset of high blood pressure in pregnancy without the presence of proteinuria (American College of Obstetricians and Gynecologists, 2013). While preeclampsia is known to impact first pregnancies more frequently, women who have had previous preeclamptic pregnancies are more likely to develop the condition in subsequent pregnancies. Up to 20% of women who have had preeclampsia once will experience it again (Roberts, 2013). The pathophysiology of preeclampsia is widely misunderstood, therefore methods to prevent

the disease process are difficult but important to identify because these women are more at risk for complicated pregnancies. Known risk factors for the development of preeclampsia are older maternal age, diabetes, and obesity, although women with none of these conditions continue to develop the disorder (Roberts, 2013). The condition affects multiple systems in the body including the heart, kidneys, coagulation system, liver, and central nervous system. Women may experience frequent headaches, blurred vision, hyperreflexia, and even seizure activity in severe cases (Duley, 2009). Due to the reduced perfusion of oxygen and nutrients through the placenta to the fetus, and general maternal vascular resistance, preterm birth, placental abruption and intrauterine growth restriction may threaten the well-being of the fetus, and affect the health of the offspring post-delivery. Prevention of the complication is important not only to protect pregnancies, but also to protect the future health of the mother. Women with preeclampsia are more likely to develop cardiovascular disease later in life (Ananth et al., 2013).

Other Common Complications

For children under 5 years old, preterm birth complications are the number one cause of death. The World Health Organization defines preterm birth as babies born alive before 37 weeks of gestation (2018). Moderate to late preterm babies, those who are born between 32 and 37 weeks gestation, have higher survival rates and fewer complications than those born before this time. Still, all preterm infants are at higher risk than full-term babies for having neonatal morbidities such as undeveloped lungs, breathing/oxygenation issues, infection, and jaundice. Children born prematurely are also more likely to have

cognitive and developmental disabilities. Smoking, obesity, and some chronic medical conditions are known to be risk factors for preterm birth (WHO, 2016).

While weight gain is expected in pregnancy, gaining more than the recommended amount for pre-pregnancy weight can make for a more complicated pregnancy. The Institute of Medicine guidelines for gestational weight gain are based on pre-pregnancy body mass index and are divided into underweight, normal weight, overweight, and obese women (Rasmussen, 2009). Approximately 48% of women in the US exceed these guidelines for gestational weight gain (Nobles, 2018). This excessive weight gain is associated with pregnancy complications such as GDM, caesarean section, large for gestational age infants, and long-term obesity for mother and baby.

Though excessive gestational weight gain increases risk for caesarean section (C-section), other factors such as GDM, previous C-section, large for gestational age infant, and obesity increase risk as well. C-sections are often associated with more risks during and after delivery than vaginal births. The Centers for Disease Control and Prevention reported that 31.9% of all births in the US in 2016 were by cesarean delivery (Martin et al., 2018). Women who deliver by C-section are more at risk for infection associate with the incision site or bladder, hemorrhage or increased blood loss compared to vaginal delivery, and injury to organs associate with surgery. These women also have extended hospital and recovery times, and have higher rates of maternal mortality compared to vaginal births (Shearer, 1993).

Purpose

While the literature presented demonstrates the multiple complications that impact the health of a mother and infant. The pathophysiology of these pregnancy complications

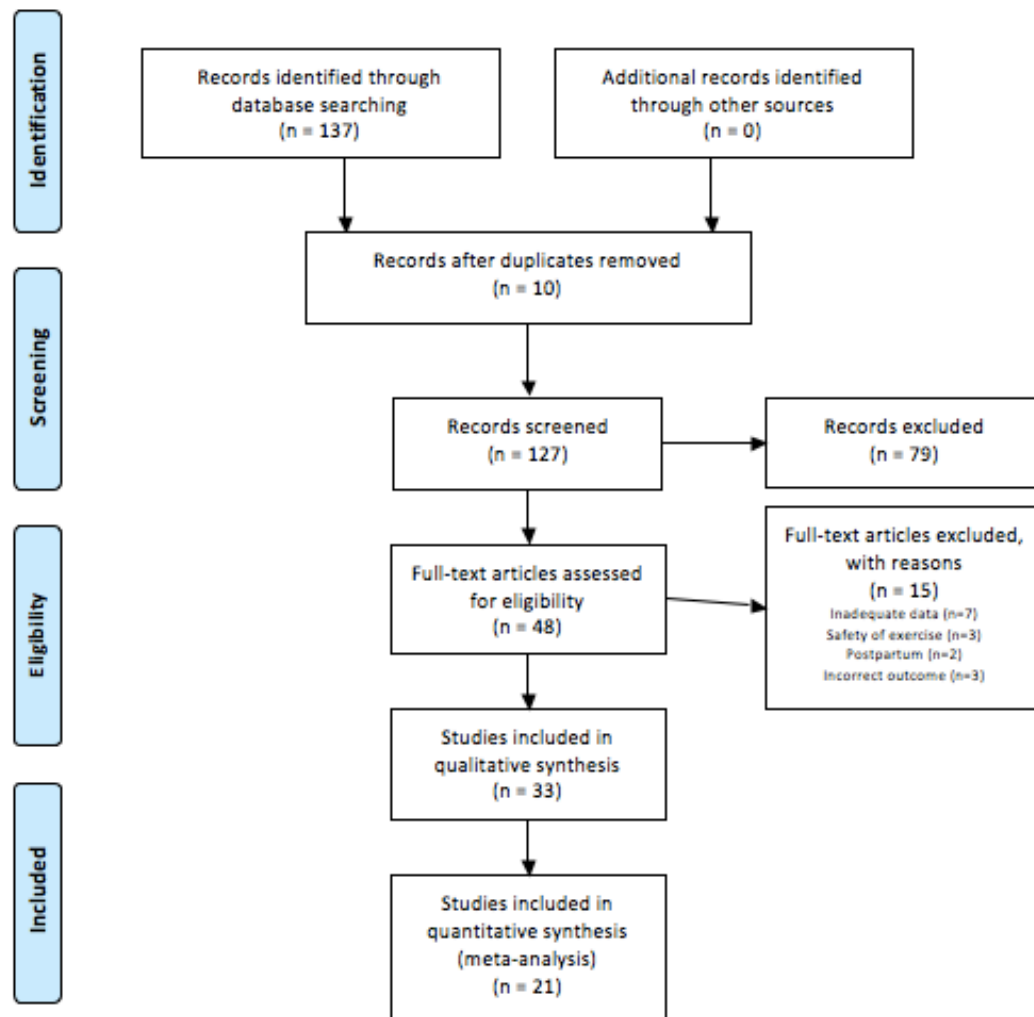
is largely cardiovascular or metabolic. Disorders arising from the cardiovascular or metabolic systems are often positively affected by increased physical activity. The purpose of this systematic review was to evaluate the effectiveness of exercise intervention during pregnancy in preventing the development of common pregnancy complications. No specific exercise intervention was targeted, but the study aimed to explore how any type of physical activity completed during pregnancy could impact outcomes for the mother and baby. While the ACOG recommends 150 minutes of moderate intensity exercise per week for all non-complicated pregnancies, many women do not adhere to this schedule often due to the physiological changes and symptoms associated with pregnancy. This study sought to answer if these recommendations for activity during pregnancy positively influence pregnancy outcomes so much as to reduce the rate of complications. This review will also attempt to analyze whether physical activity has a greater impact on reducing certain complications more than others, for example preeclampsia versus gestational diabetes.

Chapter II: Methods

A systematic literature search was performed between October 2017 and March 2018. Databases searched included PubMed, CINAHL, Cochrane, and Web of Science. Search terms used were (physical activity OR exercise OR walking) AND (pregnancy OR high-risk pregnancy OR preeclampsia) AND (complications). The search was first limited to articles published between 2003 and 2018. Studies were considered if they were peer-reviewed, performed on pregnant human female subjects, and published in English. Randomized control trials, prospective cohort studies, case control studies, and systematic reviews in which exercise was the sole intervention were included in the review.

One-hundred thirty seven full-text articles were considered for review by title screening. 10 of these articles were removed because they were duplicates. Of the remaining articles, 79 were excluded because they did not meet eligibility requirements. 48 full-text articles were then read and screened. 15 were eliminated for various eligibility issues, such as measuring exercise in postpartum rather than during pregnancy, assessing safety of exercise rather than impacts on complications, or measuring outcomes that were not of interest to this study. Of these, 21 studies were included in the final analysis (See Figure 1). Of the twenty-one selected, 11 were systematic reviews, 6 randomized control trials, 3 cohort studies, 2 case control studies, and 1 cross sectional study.

A risk of bias should be considered when interpreting the findings of this study. Only one researcher reviewed the full text articles and interpreted the data, which could possibly impact inter-rater reliability. Another limitation of this study is that articles were limited to only those published after 2003. This was done in order to reduce the number of articles that appeared in searches, but more importantly to limit the data to only up-to-date, relevant information. While older studies are important to consider, in this case specifically exercise in pregnancy was far less studied and recommended years ago. This study is also limited in the level of evidence of articles included. Only 6 of the studies included were randomized control trials, and of these most were small sample sizes.

Figure 1

Chapter III: Results

This review evaluated various exercise interventions performed throughout pregnancy. The measured outcomes varied based on the study but included preeclampsia, gestational hypertension, and gestational diabetes mellitus. Secondary outcomes measured in studies were preterm birth, C-section, and excessive gestational weight gain. Results

were evaluated based on whether or not the exercise intervention reduced the rate of the complication being studied. The summary of these results can be found in Table 1.

Table 1

Type of Complication	# of studies in which intervention reduce rate	# of studies with no difference between intervention and control
Gestational Diabetes Mellitus	7	2
Preeclampsia and Gestational HTN	5*	9*
Preterm Birth	1	2
Excessive Gestational Weight Gain	1	0
Caesarean Section	1	0

*1 study found decreased rates of gestational HTN in intervention group, but no differences for preeclampsia

Type and intensity of exercise intervention among studies varied. A summary of these results can be found in Table 2. The most common interventions were based on the ACOG recommendations of 150 minutes of moderate intensity exercise per week and simply an increase of moderate intensity exercise with varied frequency. The 11 studies that included one of these interventions did not assign participants to complete a certain type of exercise, but recommended they complete an exercise that was of moderate intensity such as walking or biking. Many of these studies used participants self reported activity to compute MET scores in order to determine their actual energy expenditure.

Several studies recommended specific exercise interventions to all participants such as pilates, yoga, stretching, walking, and stair climbing (Rodriquez-Diaz, 2017; Sorensen, 2003; Yeo, 2008; Rakhshani, Nagarathna et al., 2012). Only one study, a systematic review, studied the impact of leisure time activity in which participants were asked to increase an overall healthy lifestyle such as walking instead of driving (Aune, 2017).

Multiple questionnaires were used to evaluate participants exercise frequency and intensity, and were usually completed in postpartum. Two studies simply asked participants to evaluate the number of hours each day they spent performing activities in each of three categories; light-moderate (leaves person tired but not exhausted), moderate (leaves person exhausted but not breathless), and vigorous (leaves person breathless). Researchers then assigned MET scores (Metaabolic equivalent to task) to each activity and computed a total MET score per week for each woman. MET scores are based on the International Physical Activity Questionnaire protocol which state that one MET is equivalent to the oxygen consumption required at rest, or approximately 1 kcal/kg (Padmapriya, 2017). Based on these MET scores women were divided into groups based on the study. One of these studies (Sorensen, 2003) limited the physical activity data to the first 20 weeks of pregnancy and categorized women into only 2 groups based on their MET scores; active and not active. While another (Padmapriya, 2017) measured physical activity for the first 6 months of pregnancy and divided women into more specific groups based on the questionnaires; insufficiently active, sufficiently active, and highly active.

The Kaiser Physical Activity survey and Pregnancy Physical Activity Questionnaire were the most commonly used questionnaires. The Kaiser Physical Activity survey (KPAS) is unique in that it measures not only recreational exercise, but lifestyle activities (Fortner,

2011). The survey is divided into 4 categories of exercise: occupational activities, participation in sports and exercise, active living habits, and household and family care activities (Fortner, 2011). This survey gives women the chance to include everyday household activities such as caring for other children, cleaning, cooking, and chores in the assessment of physical activity. This is significant because while some women may not be able to complete a strict exercise regiment every day, they most likely will still be performing everyday tasks that expend energy throughout their pregnancy.

The Pregnancy Physical Activity Questionnaires (PPAQ) is a similar survey. It “evaluates participation in four domains of activities: household/caregiving, occupational, sports/ ex-ercise and transportation” (Nasiri-Amiri, 2016). This type of questionnaire was utilized in three studies to evaluate exercise during pregnancy, although time spans varied (Chasan-Taber, 2015; Nascimento; 2015; Nasiri-Amiri, 2016). One study utilized the questionnaire as part of data collection, but also offered a 12-week individualized exercise program toward the end of pregnancy. In this study the questionnaire was used to measure exercise before the intervention (Nobles, 2018).

Table 2

Type of Exercise	Number of Studies
ACOG Recommendations	5
Overall moderate intensity with varied frequency *	6
Pilates/Yoga	2
Leisure time activity	1
Walking/stair climbing	1
Stretching	1

Questionnaire divided into light, moderate, and vigorous activity	2
Kaiser Physical Activity or PPAQ **	4

*Exercises came from systematic reviews in which exercise interventions varied among studies.

**Kaiser Physical Activity Assessment/PPAQ - Measures occupational, family care, active living, and sports/exercise

The number of subjects per study greatly varied. The largest study included 1,279 women, while the smallest measured only 45. As stated above, the exercise type and frequency were extremely diverse as well. The method in which the exercise interventions were tracked in each study is also important to consider when analyzing results of each study. Self-report by a variety of questionnaires was the most common method of collection, though some randomized trials were able to supervise the physical activity being performed. A summary of these results, as well as a description of the exercise performed in each study is included below in Table 3.

Table 3

Study	Subjects	Description of exercise	How activity is assessed
Mottola, Michelle F.; Artal, Raul (2016)	Unknown due to systematic review	Counseling throughout pregnancy on physical activity. Encouraged to achieve minimum 150 minutes moderate intensity per week and to adopt “overall healthy lifestyle”.	Self reported

Study	Subjects	Description of exercise	How activity is assessed
Koivusalo, Salla B.; Rono, Kristiina; Klemetti, Miira M.; etc (2016)	293	Counseling on weight control and physical activity. Encouraged to exercise 30 minutes, 5 times per week and increase "overall healthy lifestyle". Provided with pedometers and logbooks.	Pedometer and self-report. Women only received encouragement, but could decide whether or not to exercise.
Brown, Julie; Ceysens, Gilles; Boulvain, Michel (2017)	638 (11 studies)	Moderate intensity exercise based on ACOG guidelines. Frequency varied due to systematic review.	Self reported
Han, Shanshan; Middleton, Philippa; etc. (2012)	1115 (5 trials)	Multiple exercise interventions all based on moderate intensity recommendations. Varied due to systematic review.	Self reported
Meher, Shireen; Duley, Leila (2006)	45 (2 studies)	Moderate intensity aerobic exercise. Frequency varied due to systematic review.	Self reported
Rodriguez-Diaz, Luciano; Ruiz- Frutos, Carlos (2017)	105	Sessions of pilates based program two times per week for 8 weeks. Sessions were supervised by instructors.	Supervised activity in pilates classes
Aune, D; Schlesinger, S.; Henriksen, T (2017)	41 studies	Higher intensity leisure time activity with varied frequency due to systematic review.	Self reported
Padmapriya, Natarajan; Bernard, Jonathan Y; Liang, Shen (2017)	1083	Categorized into light-moderate (leaves person tired but not exhausted), moderate (leaves person exhausted but not breathless), and vigorous (leaves person breathless).	Self reported based on questionnaire which measured MET scores based on intensity of activity.

Study	Subjects	Description of exercise	How activity is assessed
Zheng, J; Wang, H; Ren, M (2017)	1872 (5 studies)	Systematic review with 2 studies performing supervised cycling classes 3 times per week. 3 studies obtained physical activity via questionnaire and recommended ACOG guidelines.	Supervised and self reported
Tanya K. Sorensen, Michelle A. Williams, I-Min Lee, etc. (2003)	587	Recreational physical activity divided into: light/moderate, vigorous, and brisk walking/stair climbing	Self reported questionnaire which assigned MET scores to each activity performed
Fortner, Renee Turzanski; Pekow, Penelope S.; etc. (2010)	1231	Measured occupational activities, sports and exercise, active living habits, household and family care activities. Asked to report how many hours per day these activities were performed.	Self reported using Kaiser Physical Activity survey
Lisa Chasan-Taber, Marushka Silveira, Penelope Pekow, etc. (2015)	1240	Evaluated participation in sports exercise, household/caregiving, occupational, and transportation activities per day. Amount of minutes in each activity per day were calculated and MET scores assigned.	Self reported using PPAQ (pregnancy physical activity questionnaire)
SeonAe Yeo, Sandra Davidge, David L. Ronis, etc. (2008)	79	Groups divided into either walking or stretching exercises which were to be performed 5 times per week. Walking averaged 30 minutes per day, stretching 40 minutes per day.	Walkers used pedometers Stretchers self reported
Nascimento SL, Surita FG, etc. (2015)	1279	Walking and water aerobics were most commonly reported among the moderate intensity exercises studied. Type and frequency of each were assessed.	Self reported using PPAQ which were given after delivery
Aune D, Saugstad OD, Henriksen T, Tonstad S (2014)	15 studies	Exercises varied due to systematic review but MET scores per day were assigned in each study.	Self reported

Study	Subjects	Description of exercise	How activity is assessed
Russo LM, Nobles C, Ertel KA, etc. (2015)	3,401 (10 studies)	Systematic review so exercises varied. 6 of these studies used supervised group exercises. 2 studies were individual and self reported. 2 studies used combination of the two.	Supervised and self reported
Nobles, Carrie; Marcus, Bess H; Stanek, Edward J (2018)	241	12 week individually tailored program designed to increased compliance. All programs based on ACOG guidelines and encouraged increased walking.	Self reported using PPAQ
da Silva, Shana Ginar; Hallal, Pedro (2017)	639	Exercise program started between 16-20 weeks gestation and done for 16 weeks. Structured and individually supervised moderate activity based on ACOG guidelines. Included warm up, aerobic and strength activities, and stretching for 1 hour, 3 times per week.	Supervised activity and training diary
Rakhshani, A; Nagarathna, R; etc. (2012)	68	Supervised yoga program by certified instructors	Supervised activity
Nasiri-Amiri, Fateme; Bakhtiari, etc. (2016)	200	Measured activity in household/caregiving, occupational, sports/exercise, and transportation. Assigned MET scores based on activity level.	Self reported using PPAQ
Magro-Malosso ER, Saccone G, etc. (2017)	5075 (17 trials)	Aerobic exercise with differing frequency due to systematic review.	Self reported

Chapter IV: Discussion

Gestational Diabetes Mellitus

This review showed mixed results in terms of how exercise interventions impacted the development of pregnancy complications. As seen in Table 1, gestational diabetes was reduced by exercise intervention in 7 studies (Koivusalo et al., 2016; Padmapriya et al., 2017; Zheng et al., 2017; Russo et al., 2015; Rakhshani et al., 2012; Nasiri-Amiri et al., 2016), but no difference was found between intervention and control groups in 2 studies (Han et al., 2012; da Silva et al., 2017). Of the studies that found a reduced rate of complication two studies were meta-analyses (Russo et al., 2015; Zheng et al., 2017). In these, the studies included for analysis all included some form of aerobic exercise, though the frequencies varied. One of randomized control trials which reduced rates of GDM in the review was a high-quality trial which consisted of supervised intervention 3 times per week including strength, aerobic, and stretching activities (Zheng et al., 2017). The average duration of exercise in one review ranged from 105-240 minutes per week (Russo et al., 2015). A randomized control trial involving 293 women found decreased GDM for the participants in the exercise group. These women were encouraged to achieve a minimum of 150 minutes of moderate intensity physical activity per week throughout their pregnancy. Women were given counseling, but were ultimately responsible for deciding whether or not to exercise. To aid in encouragement they were given free access to public swimming pools and guided exercise groups once per week (Koivusalo et al., 2016). Another study examined only the last 6 months of pregnancy and measured light-moderate, moderate, and vigorous activity. MET scores were assigned to each activity and then women were divided into insufficiently, sufficiently, and highly active groups. The sufficiently and highly active groups were based on WHO recommendations and those who were classified as

sufficiently active exercised an average of 30 minutes per day, 5 times a week (the ACOG recommendations for pregnant women). Both of these groups saw a decreased rate of GDM (Padmapriya et al., 2017).

Multiple studies chose to focus on exercise in early pregnancy (Rakhshani et al., 2012; Nasiri-Amiri et al., 2016). Results of a study that measured physical activity using the PPAQ found that increased levels of moderate activity in the first 20 weeks of pregnancy reduced the incidence of GDM (Nasiri-Amiri et al., 2016). The only study that utilized yoga as an exercise intervention also found decreased GDM in participants. Certified yoga instructors supervised one-hour sessions, three times per week between 12-28 weeks gestation (Rakhshani et al., 2012). Because the exercise interventions in each study varied greatly, it is difficult to conclude which specific activity type may be most effective at lowering risk for GDM.

Of the two studies which found no difference in GDM rates between intervention and control groups, one was a systematic review (Han et al., 2012) and another a randomized control trial (da Silva et al., 2017). The systematic review included five randomized control trials, but of these, four were completed with small sample sizes. Exercise interventions varied between individualized programs with advice, supervised exercise sessions, and at home cycling, though none of these were found to impact risk of GDM (Han et al., 2012). The randomized control trial (da Silva et al., 2017), which found no conclusive results, studied an exercise program started between 16 and 20 weeks gestation. The supervised program continued for at least 16 weeks and included one-hour sessions, 3 times per week based on the ACOG recommendations. Each session involved a warm up, aerobic, strength, and stretching periods. The length of each activity gradually

increased every 5 weeks. This study was one of the first large-scale, randomized control trial to attempt to reduce GDM incidence using supervised intervention, but ultimately did not achieve wanted results. Though more studies included in this review found that exercise decreased the rate of GDM, there is insufficient evidence to draw conclusions from this data due to the presence of these conflicting results.

Gestational Hypertension and Preeclampsia

The results from studies examining preeclampsia and gestational hypertension as primary outcomes are also difficult to interpret. A larger number of studies (9) found no difference between intervention and control groups, compared to the 5 studies that saw the intervention reduce the rate of hypertensive disorders. The same randomized control trial that found decreased rates of GDM, also saw a reduced number of women with preeclampsia in the intervention group. This study used supervised yoga sessions three times per week between 12-28 weeks gestation (Rakshani et al., 2012). Meta-analysis was utilized in two of the studies that found reduced rates of preeclampsia and gestational hypertension (Aune et al., 2014; Magro-Malosso et al., 2017). One of these used 15 cohort and case control studies to measure walking and overall physical activity. Combining data from each study, researchers found walking and greater intensity of exercise in early pregnancy to be inversely related with preeclampsia (Aune et al., 2014). The second meta-analysis had more specific parameters for exercise intervention in the 7 studies it included in analysis. Each study assigned women in the intervention group to aerobic exercise for 30-60 minutes of exercise two to seven times per week in early pregnancy. There was a significant reduction in gestational hypertension for these women, but no significantly significant difference in rates of preeclampsia (Magro-Malosso et al., 2017).

One case control study recruited 587 women post-delivery to fill out a questionnaire designed to measure physical activity in the first 20 weeks of pregnancy (Sorensen et al., 2003). Researchers assigned MET scores to activities and, after combining scores, classified women as either active or inactive. Due to the case control nature of the study the type of activities performed by women greatly varied but intensity was divided into light, moderate, and vigorous. The study saw a 34% reduced risk of preeclampsia for the women who participated in any form of recreational activity, and an even more drastic reduction of 54% for women who did vigorous activity in early pregnancy (Sorensen et al., 2003). The final study, which found reduced risk of preeclampsia with increased activity, was a prospective cohort study (Fortner et al., 2010). Using the KPAS (Kaiser Physical Activity Survey) interviewers determined women's physical activity levels during early pregnancy. The survey measured four domains of activity: occupational activity, active living habits, sports and exercise, and household and family care. The measurement of household, family care, and occupational activities were unique to this study and important to note. Women were divided into quartiles based on their activity level in each domain. The study found that women in the highest quartile for each activity had a lower risk for hypertensive disorders compared to women in the lowest quartile. Although the risk was lower in more active women, the results were not statistically significant because a small number of women actually developed the disorders. Though this study was well designed and had a large sample size, this may be due to the fact the study did not include women who were considered at increased risk for developing the diseases (Fortner et al., 2010).

More studies found that exercise had no impact on the risk of developing hypertensive disorders in pregnancy (Brown et al., 2017; Han et al., 2012; Meher et al.,

2006; Zheng et al., 2017; Chasan-Taber et al., 2015; Yeo et al., 2008; Nascimento et al., 2015; da Silva et al., 2017; Magro-Malosso et al., 2017). Four of these studies were systematic reviews, making the type and frequency of exercise difficult to standardize (Brown et al., 2017; Han et al., 2012; Meher et al., 2006; Zheng et al., 2017). An issue to note with one of these reviews (Brown et al., 2017) is that it only included women who had been diagnosed with gestational diabetes. Therefore, preeclampsia was measured as a secondary outcome and not the focus of the review. Only 2 of the randomized control trials included in the 11-study review measured preeclampsia and both were small trials (including only 48 women total). The women in the intervention group for both of these trials were enrolled in moderate intensity exercise programs (Brown et al., 2017). Small sample size was a common problem among all systematic reviews. A systematic review studying five randomized control trials had only one study with a sample size larger than 100 (Han et al., 2012). The exercises among these five trials varied from individualized exercise, regular advice, weekly-supervised group exercises, and home stationary cycling. None of these trials found that preeclampsia rates were impacted by the exercise interventions (Han et al., 2012). The results were similar for a systematic review that also studied two small trials, 45 women total (Meher et al., 2006). In both randomized control trials, women in the intervention group were assigned to increase their moderate intensity aerobic exercise but found no difference in preeclampsia rates (Meher et al., 2006). The final systematic review had greater numbers (1872 participants across 5 trials), but still found no difference in preeclampsia rates across groups (Zheng et al., 2017). All five trials studied recommended exercise in early pregnancy (varying between 10-22 weeks) based on the ACOG recommendations of 150 minutes of moderate intensity exercise per week to the

intervention groups. Importantly, this review found that these women had lowered risk of gestational diabetes, but the risk of preeclampsia was not impacted by the exercise (Zheng et al., 2017). Two large studies utilized the PPAQ (Pregnancy Physical Activity Questionnaire) in postpartum to evaluate women's exercise during pregnancy (Chasan-Taber et al., 2015; Nascimento et al., 2015). Both studies had sample sizes of over 1,000 and used the PPAQ to divide women into groups of active (meeting ACOG standards) and inactive. The most common exercises reported in one study were walking and water aerobics (Nascimento et al., 2015). Neither of these studies found differences in preeclampsia rates between active and inactive women (Chasan-Taber et al., 2015; Nascimento et al., 2015). Only two studies were randomized control trials and both began exercise interventions between 16-20 weeks gestation and continued until delivery (da Silva et al., 2017; Yeo et al., 2008). One of these was the same study that found no difference in gestational diabetes rates when women were assigned to an individually supervised, moderate-intensity program (da Silva et al., 2017). The hour sessions, performed three times per week beginning at 16 weeks gestation had no impact on the rates of preeclampsia (da Silva et al., 2017). Women in the second randomized control trial were split into two exercise groups; walking and stretching (Yeo et al., 2008). The walking group was designed to encourage ACOG recommendations, while the stretching group performed low intensity, low impact activities. Each of the groups were encouraged to do their assigned exercises five times per week beginning at 18 weeks gestation, but neither group saw differences in preeclampsia rates (Yeo et al., 2008). The same meta-analysis mentioned above that found decreased rates of gestational hypertension, interestingly found exercise

had no impact on the number of women who developed preeclampsia (Magro-Malosso et al., 2017).

Preterm Birth, Excessive Gestational Weight Gain, and C-Section

Secondary outcomes were measured in few of these studies. Preterm birth, measured in three studies, was found to be reduced in one study and unchanged by exercise in two (Aune et al., 2017; Zheng et al., 2017; da Silva et al., 2017). The two studies that found no change in risk have already been discussed above and were one meta-analysis and one randomized control trial (Zheng et al., 2017; da Silva et al., 2017). The only study, which found decreased rates of preterm birth with exercise intervention, was a large systematic review that included 20 randomized control trials and 21 cohort studies (Aune et al., 2017). The review focused on studies that measured leisure time exercise in early pregnancy. Combining data from these studies, researchers found a 10-14% reduced risk of preterm birth for women who had higher levels of leisure time activity (Aune et al., 2017). The single study that examined excessive gestational weight gain found decreased levels of the complication with randomly assigned exercise intervention (Nobles et al., 2018). The randomized control trial assigned women in the intervention group to a 12-week individually tailored exercise program that encouraged 30 minutes of exercise five times per week. Walking was emphasized as an important activity to include in workouts. Based on the Institute of Medicine guidelines for weight gain during pregnancy, women in the exercise group were found to be at a 30% reduced risk of exceeding recommendations (Nobles et al., 2018). The results were significant for the study, but sample size was small (241 participants). The only study that measured C-section risk was a small-scale

randomized control trial, which used a Pilates based program as the intervention (Rodriquez-Diaz et al., 2017). Women in the intervention group participated in one-hour supervised Pilate's classes twice a week for 8 weeks mid-pregnancy. The women in the intervention group saw decreased rates of C-section as well as improved blood pressure, although sample sizes were small (Rodriquez-Diaz et al., 2017).

Limitations

There were several common limitations found across all studies. There were few studies that included more than 300 participants (see Table 3) and among these women included a small percentage of them actually developed the complications being studied. Due to low numbers, many of the results were determined not to be statistically significant. There is also high-risk of bias in many of these trials. All but a few studies relied on women to self-report their physical activity behaviors, often months after they had performed the exercise (see Table 3). It is difficult to evaluate the accuracy of the survey measurements used such as the KPAS and PPAQ. Due to the physical changes related to pregnancy, many women failed to adhere to specific exercise interventions throughout the studies, and dropout rates were high in most randomized control trials. It is also difficult to draw conclusions on which specific exercise has the most impact on reducing rates because almost every study had varied types of exercises being performed by participants. Though the ACOG recommendations were often used as a guide for research in which participants were encouraged to engage in moderate intensity exercise, it is difficult to determine the exact level of intensity for many exercises when women were unsupervised.

Chapter V: Conclusions

Though results were extremely diverse, several conclusions and recommendations can be drawn from this study. The majority of studies found that gestational diabetes risk could be reduced by exercise intervention, though multiple studies found no impact. The opposite was found true for preeclampsia; more studies saw no effect of exercise on changing the rates of the disease. Firstly, all twenty-one studies included in this review confirm current recommendations that moderate exercise during uncomplicated pregnancy is safe for both mother and baby. The benefits associated with physical activity across the lifespan carry over into pregnancy and women experiencing normal pregnancy should continue to engage in exercise (American College of Obstetricians and Gynecologists, 2015). The benefits associated with continuing exercise in pregnancy far outweigh the low risks for the majority of women. Based on these findings, this review has clinical implications for women's health care providers. Because this research indicates that exercise presents no increased maternal or fetal risk, providers should include recommendations for prenatal exercise as part of the initial prenatal visit as well as throughout pregnancy. Past perceptions that exercise during pregnancy was harmful for the fetus still loom in the minds of some mothers, so education on the safety of activity is ever important to improve maternal and fetal outcomes. Practitioners should be encouraged to guide women through the process of continuing, or beginning, an exercise regiment during pregnancy.

As a result of this review, we see inconsistent results, which are most likely based on the varying measures of exercise used, outcomes measured, inclusion criteria of participants, and prescribed exercises. The only factor consistent among all studies was the

diagnostic criteria for the conditions being studied, for example all trials measuring preeclampsia utilized the ACOG guidelines for diagnosis (Roberts, 2013). As discussed above, multiple surveys were used to evaluate physical activity during pregnancy in cross sectional, case control, and cohort studies. While these questionnaires have similarities, it is unclear if the interpretation of the results is consistent. Researchers using surveys as their method of collection determined physical activity level by assigning MET scores to each exercise, but these scores differed among studies. Guidelines for tools used to measure exercise in pregnancy must be developed in order to standardize results.

A major issue in comparing these studies is the lack of consistency among exercise types and frequencies. For case control, cross sectional, and cohort studies it is difficult to control for type of exercise because women are being surveyed after having done these exercises and no intervention is applied. However, even for randomized control trials women were often assigned very ambiguous instructions for exercise such as “perform 30 minutes of moderate intensity exercise three times per week”. From these criteria it is then difficult to determine which type of exercise is truly the most beneficial because women could be performing a wide variety of exercises.

Supervision of exercise is a major component in determining the accuracy of intervention measurements, and this was only seen in five of the twenty-one studies. Self-reporting was utilized in every other study and in many of them was completed months after women had performed the exercises. It is difficult to determine how accurate these measurements are because of the wide range of recall time. Women who are enrolled in studies in which they are asked to attend classes, or receive specialized, individualized training are held accountable for the exercises being performed and are not given the

opportunity to fictionalize their participation. The results of these high quality studies can then be better trusted because of the low risk of bias. Further research should focus on creating high quality randomized control trials that include supervised activity as the intervention.

Due to the small number of high-quality trials and lack of consistency in results it is obvious that future research on this topic is indicated. Exercise is a low risk intervention that can be applied to most healthy pregnant women, making it a safe to study in large numbers. It is essential to standardize the correct dosing in terms of type and frequency of exercise for pregnant women to reap the most benefits. Women should continue to follow health care providers instructions for exercise based on their pregnancy situation. The actions women take while pregnant have major implications for not only their health, but also the future health of their children. This population requires more attention in research in order to ensure the health of future generations.

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